
Working Paper



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**THE IMPACT OF FISCAL POLICY ON
THE RISK PREMIUM OF GOVERNMENT
LONG-TERM DEBT: SOME CANADIAN EVIDENCE**

By

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Summary

The purpose of this study is to determine the impact of fiscal policy on the risk premium associated with provincial long-term debt. The underlying hypothesis is that there exists a market mechanism which discourages unsustainable borrowing with risk premia that rise at an increasing rate with protracted debt accumulation. Thus, the supply of credit is expected to be highly non-linear, thereby inducing sustainable borrowing as a result of accelerating debt-servicing charges.

The evidence derived from four Canadian provinces supports the contention of a market-imposed fiscal discipline. With British Columbia acting as a reference point from which to evaluate the other provinces, the supply of credit is represented as a function of the yield spread between long-maturity bonds. Linear supply models indicate that an additional percentage-point change in the debt-to-GDP ratio causes an increase in the yield spread of 2.0 to 2.6 basis points. The data also support the notion of a non-linear supply curve. The non-linearity of the supply function becomes particularly pronounced compared to the linear model as the difference in the debt-to-GDP ratios exceeds 35 to 50 percentage points.

Résumé

Cette étude a pour but de déterminer l'impact de la politique budgétaire sur la prime de risque associée à l'endettement provincial de long terme. On fait l'hypothèse sous-jacente qu'il existe un mécanisme de marché par lequel des emprunts non-soutenables sont découragés via une prime de risque qui augmente à un taux croissant avec le niveau d'endettement. Ainsi, l'offre de crédit devrait se présenter sous une forme non-linéaire, n'encourageant ainsi que des emprunts soutenables grâce au mécanisme régulateur du service de la dette.

Les résultats tirés de quatre provinces valident l'hypothèse d'une discipline budgétaire imposée par les marchés financiers. La Colombie-Britannique agissant comme province de référence à partir de laquelle on compare les autres provinces, une offre de crédit est représentée comme étant fonction de l'écart de rendement entre les obligations de long terme. Les modèles d'offre linéaire indiquent que chaque point de pourcentage additionnel du ratio de la dette au PIB déclenche une augmentation de l'écart entre les taux de rendement de 2.0 à 2.6 points de base. Les données entérinent également l'hypothèse d'une courbe d'offre non-linéaire. La non-linéarité de cette dernière devient particulièrement prononcée par rapport au modèle linéaire lorsque la différence du ratio de la dette au PIB atteint de 35 à 50 points de pourcentage.

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1.0 Introduction

An increasingly important issue confronting macroeconomic policy authorities in Canada is the impact of persistent fiscal imbalances on the cost of borrowing. The nature of the relationship between interest rates and the public debt has been studied by economists for many years. Keynesians linked fiscal expansionism to a higher induced real interest rate, resulting in the crowding out of current investment or net exports and diminishing future productivity. The same qualitative relationship can be derived from capital theory. The finance paradigm suggests that lenders require a risk premium as compensation for the additional probability of default that results from protracted debt accumulation. The objective of this paper is to determine the relationship between fiscal policy and the perceived riskiness of government debt in three Canadian provinces.

Fiscal consolidation has accelerated rapidly at the provincial level over the past several years. In the current fiscal year, seven provinces expect a balanced budget or surplus compared to only one in 1993-94¹. Many jurisdictions have even introduced schedules for the repayment of the public debt². In this context, it is important to understand the effect on interest rates that accrues from fiscal constraint. The benefit of a lower deficit- and debt-to-GDP ratio in terms of a reduced risk premium is a major rationalization for fiscal restraint measures. A frequent extension of this argument is that the foregone loss in current social welfare that results from reductions in program spending, will be more than offset by lower future borrowing costs.

The assertion that interest rates will decline with further restrictive fiscal measures is seldom contested. Although there is little statistical support for this view, casual evidence suggests a loose relationship between consolidation and interest rate reductions in Canada. However, more rigorous evidence is suitable for the proper determination of public policy. A lower risk premium reduces the government's debt-servicing costs and may yield greater revenues following increased economic activity. Furthermore, the nature of the risk premium can contribute to the determination of the optimal debt-to-GDP ratio. If the risk premium is low and stable within a certain range of debt, then further reductions in net debt may not warrant the resulting sacrifice to public services, (although there are other reasons a government may want to reduce the debt such as increasing the "room to manoeuvre or enhancing inter-generational equity). On the other hand, the relationship may indicate that a very low, or even the elimination of the public debt is optimal. As a result, the non-linearity of the relationship is a significant factor in future fiscal policy

¹ Ontario, Québec, Newfoundland and the territories are the only jurisdictions remaining that have a budget deficit in 1996-97, although plans have been set out for the elimination of those deficits.

² British Columbia, Alberta and Manitoba have introduced debt repayment schedules.

decisions regarding the magnitude of expenditure reductions that are required to obtain the optimal debt-to-GDP ratio.

In addition to the fiscal policy dimension, the relationship between the risk premium and fiscal policy has important implications in a very different context, that of European integration. Under the terms of the Maastricht Treaty, a degree of fiscal convergence is required before the implementation of the monetary union. The deficit- and debt-to-GDP reference targets of 3 per cent and 60 per cent, respectively, seem increasingly unattainable in many EC member countries. As a result, the European Community may be compelled to contemplate alternative mechanisms to attain fiscally sustainable behaviour. The market-discipline hypothesis posits that lenders demand a risk premium which escalates at an increasing rate with unsustainable debt accumulation. In the limit, the risk premium increases asymptotically which effectively constrains the level of credit available to governments. Empirical support for a market mechanism that penalizes unsustainable policies would suggest that convergence rules are superfluous in the medium-to-longer term, or at best, complementary to the market³.

The approach applied in this paper is to estimate the supply of credit available to a sample of three provincial governments: Ontario, Québec and Nova Scotia. These three provinces were selected in order to contrast the estimates of provinces that are subject to quite different fiscal situations. As the largest provincial borrower, Ontario accounts for a significant proportion of the total provincial debt burden⁴. Québec also faces a relatively large debt burden, in addition to risk related to political uncertainty. Finally, Nova Scotia represents the case of a smaller borrower operating in a constrained fiscal environment. Nova Scotia is much more dependent on federal cash transfers, and is limited by a smaller economic base than either Ontario or Québec⁵. However, the province remains an active player in capital markets allowing for the empirical identification of the impact due to these differences.

The risk premium is defined as the yield spread between long-maturity provincial bonds denominated in Canadian dollars. This measure isolates the default risk by mitigating other influences such as the exchange rate and inflationary risk. In addition, the data adjust for differing coupon rates and callability options⁶. The spread is therefore a measure of the *relative* default risk between two provinces. The risk premium in all three cases is defined in terms of the yield of a British Columbia bond, which acts as the reference point to identify relative risk. The default risk in British Columbia

³ Goldstein and Woglom (1992) and Bayoumi et al (1995) provide an interesting discussion of the market-based fiscal discipline hypothesis, particularly as it relates to European monetary integration.

⁴ In 1995-96, net debt in Ontario accounted for 45.4 percent of the total provincial-territorial total on a Public Accounts basis.

⁵ Federal cash transfers represented 43.0 percent of Nova Scotia's total revenue in 1995-96, compared to 21.3 percent in Québec, 16.2 percent in Ontario and 12.1 percent in British Columbia.

⁶ The data are obtained from Scotia McLeod's fixed-income research department.

should be low and stable in comparison to the other provinces because of its favourable financial situation over the sample period. British Columbia had an accumulated surplus position for many years, which has only recently shifted to a net debt situation.

The extent of non-linearity in the relationship between the yield spread and relative debt is inferred from the estimates and contrasted with the findings of researchers investigating the risk premium in US states and across OECD countries. The Canadian evidence supports a statistically significant non-linear relationship between the risk premium and public debt. The results for Ontario and Nova Scotia conformed to the expected outcome that relative fiscal policy performance impacts the yield spread. The results for Québec also confirmed this view, however the quality of the statistical results was not as strong as in the other two cases. Further, the cointegration of the yield spread and the relative debt-to-GDP ratios for each province supports the argument that a long-run equilibrium relationship exists between these variables.

The next section surveys the literature and summarizes the findings of major contributions to this area of inquiry. The subsequent section explores theoretical issues, focusing in particular on the market-discipline hypothesis. Section 4 presents the data and investigates the possibility of Cointegration relationships. Finally, the empirical methodology and results are presented, followed by some concluding remarks.

2.0 Review of the Literature

Unfortunately, the literature is relatively limited in this area of research. Much of the existing literature has focused on the behaviour of US states in the context of its applications to European integration. Nevertheless, there are several papers that are particularly important for the research conducted in our study.

Goldstein and Woglom (1992) investigated the relationship between the relative fiscal policy performance of American states and the yield spread between 20-year, general obligation state bonds. Their objective was to relate the experience of the United States, as a federal political structure and monetary union, to the issues involving European monetary and political integration. In particular, Goldstein and Woglom tested the hypothesis that the market could supplant the fiscal rules mandated under the Maastricht Treaty in order to encourage fiscal convergence among EC member countries.

Their work was a major advance in the literature for several reasons. First, it exploited a previously unused data set containing long-term bond yields of US states that were coupon adjusted and shared identical callability

and maturity characteristics. Second, they acknowledged the possibility of a simultaneity bias if the government's demand for credit is interest sensitive. Further, the supply of credit in their paper is based on capital theory, providing a rigorous theoretical foundation. Finally, they obtained an index of the relative strictness of the fiscal rules prevailing in US states, allowing for a measure of the impact of these rules on the default risk.

Table 1 summarizes the principle conclusions developed in the literature. Goldstein and Woglom found evidence that supported the responsiveness of the risk premium to fiscal-policy variables and fiscal rules. However, they could not establish strong support for the non-linearity of the supply of credit. The impact of an additional percentage point in debt ranged from 8.3 basis points, before accounting for the simultaneity bias, to 19.7 basis points using a two-stage least squares procedure. Fiscal rules were also found to be strongly significant, decreasing the risk premium by two basis points for a percentage-point change in their index of strictness. Following these results, they concluded that fiscal rules complemented the market mechanism.

Although an important contribution, there were several econometric problems in the Goldstein and Woglom paper. The possibility that the time series are non-stationary was not addressed, which may have resulted in a spurious regression. Another problem, which they acknowledged, was that the instruments that they chose are themselves very likely to affect the probability of default in addition to the demand for credit. Metcalf (1990) argued that demographic variables are important exogenous determinants of the government's demand for credit. However, these variables are also likely to affect the probability of default because rational investors would identify demographic pressures as increasing the long-run demand for credit and therefore the sustainability of a given fiscal regime.

A later paper, by Bayoumi, Goldstein and Woglom (1995), built on the earlier paper and introduced a regression specification based on tighter theoretical underpinnings. The following section of this paper, which develops theoretical issues, expounds on the framework developed by Bayoumi *et al*, and is therefore not repeated here. In general, their specification is attractive because it nests a linear model within a highly non-linear equation. The nested model allows for tests of the appropriate parameters in order to identify the statistical superiority of the two specifications. The results of parameter tests provided strong support for a non-linear supply curve. Point estimates demonstrated that at the mean level of state debt (3.7% of GSP at the time their paper was written), the risk premium would increase by 23 basis points for every percentage-point increase in debt. Further, debt levels that are approximately 8 to 9 percent of GSP would result in credit rationing.

Table 1
Summary of the Literature

Study	Non-Linear Supply	Impact of Debt-to-GDP Ratio (basis points)	Rules	Comments
Goldstein and Woglom (1992)	Rejected non-linearity	OLS: 8.3 2SLS: 19.7	2.0	
Bayoumi, Goldstein and Woglom (1995)	Highly non-linear.	2SLS: 23	Up to 50 basis points.	Estimate applies at mean level of US state debt. Credit rationing at 25% of GSP.
Alesina <i>et al</i> , (1992)	Not applicable.	1½ basis points for every %-point in additional debt to GDP.	Not applicable.	
Carter and Rousseau, (1986)	No	Québec: 3-5 N-B: 1 ON, BC: 0	Not applicable.	
Delorme and Mattina (1996)	Non-linear model supported.	Linear: ON: 2.57 QU: 2.15 NS: 2.01 Non-linear: ON: .05 QU: .04 NS: .03	Not applicable.	The coefficients corresponding to the non-linear model relate a change in the difference of squared debt to the yield spread.

Alesina, De Broeck, Prati and Tabellini (1992) provided an international comparison of the risk premium in a sample of twelve OECD countries during the 1978 to 1989 period. They found a strong correlation between the size of public indebtedness and the spread between public and private rates of return when a country was characterized as having a high or unsustainable level of public debt. They argued that the use of this measure allowed them to distinguish between the default risk and the risk of devaluation. The countries that were considered to have a high, or rapidly growing debt relative to GDP included Ireland, Belgium, Italy,

Denmark, the Netherlands and Spain. Their results suggest that high-debt countries pay a premium of 1 1/2 basis points for every percentage point of debt relative to GNP. Canada, however, was not included in the set of highly indebted countries.

The most recent study of the Canadian experience was conducted by Carter and Rousseau (1986). Although the study is somewhat dated, and the significant increase in public debt was only commencing in many provinces, the results continue to be useful for this analysis. Carter and Rousseau investigated the influence of the debt on the long-term bond yields of four Canadian provinces: British Columbia, New Brunswick, Ontario and Québec. They estimated the main determinants of the yields and of the spread relative to the federal long-term bond rate for the 1960 to 1982 period.

Carter and Rousseau formed several important conclusions based on their research. First, the bonds issued by Ontario and British Columbia are close substitutes to federally issued bonds. However, the spread is influenced by the level of the yields. Second, the risk premium was significantly correlated to the level of debt in Québec, and to a lesser extent in New Brunswick. A rise of one percentage point in the debt-to-GDP ratio increases the risk premium by 3 to 5 basis points for Québec bonds, and by almost one basis point for New Brunswick bonds. Third, since the level of debt in BC and Ontario were relatively low in comparison to New Brunswick and Québec, they could not conclude that an increasing level of debt leads to an increase in the risk premium, except for provinces with a relatively high debt-to-GDP ratio. Fourth, political and socio-economic events in Québec dominated innovations in the yield spread during the 1970 to 1982 period. Finally, when regressing a weighted average of the yields on the bonds of all provinces and total provincial debt, they found a significant correlation between debt and spreads which would imply an increase of 3 basis points for a one percentage point increase in the debt-to-GDP ratio.

3.0 Theoretical Background

An important postulate advanced in finance theory is that risk-neutral and rational investors will exploit arbitrage opportunities until the expected return among different classes of risky assets are equalized. Otherwise, capital would flow to the investment offering the highest expected yield. This basic relationship provides the theoretical foundation for the empirical work presented in this paper.

The condition that expected returns are equal in equilibrium can be derived from a simple two-period representative-agent model. Preferences are time additive and defined over a single composite consumption good, indexed by time. Agents can invest in either a riskless asset, denoted TB and yielding a return of r , or in an asset with non-zero risk denoted D and offering a return of ι . Endowments are defined as Y_0 and Y_1 , in the first and second periods, respectively. Lump-sum taxes (τ_0, τ_1) are deducted from the endowment in each period, however they do not affect the equilibrium solution. The budget constraints require that the outlays of each period not exceed the financial resources available in that period. The optimization problem is presented below:

$$\max U = U(C_0) + \beta U(C_1)$$

subject to:

$$P_0 C_0 + TB_0 + D_0 + \tau_0 = Y_0$$

$$P_1 C_1 = (1+r)TB_0 + (1+\iota)D_0 + Y_1 - \tau$$

The rate of interest subject to risk must exceed the riskless return for assets characterized with non-zero risk. Maximizing utility subject to the intertemporal budget constraints derives the equilibrium solution, which is developed on the next page. The equilibrium condition requires that the risk-free rate of interest equal the expected return of the asset subject to risk times the marginal utility per dollar in the future, discounted by the marginal utility per dollar in the current period.

Assuming risk-neutrality implies that the marginal utilities are constant. Allowing for this simplification reduces the equilibrium expression to the equality of expected returns:

$$(1+r) = E_0(1+\iota)$$

In this case, the source of risk is derived exclusively from the probability of default. The portfolio risk, defined as the risk to the return of the entire portfolio due to the return of a single constituent asset, is assumed to be fully diversified⁷.

⁷ Following the assumption in Goldstein and Woglom (1992).

Model Derivation:

$$\max_{\{D_0, TB_0\}} U = U\left(\frac{Y_0 - TB_0 - D_0 - \tau_0}{P_0}\right) + \beta E_0 U\left(\frac{(1+r)TB_0 + (1+i)D_0 + Y_1 - \tau_1}{P_1}\right)$$

FOC:

$$D_0: 0 = U'(C_0)\left(\frac{-1}{P_0}\right) + \beta E\left[\frac{U'(C_1)(1+i)}{P_1}\right]$$

$$\left(\frac{U'(C_0)}{P_0}\right) = \beta E\left[\frac{U'(C_1)(1+i)}{P_1}\right]$$

$$[1] \quad 1 = \beta E\left[\frac{\frac{U'(C_1)(1+i)}{P_1}}{\frac{U'(C_0)}{P_0}}\right]$$

$$TB_0: 0 = U'(C_0)\left(\frac{-1}{P_0}\right) + \beta E\left[\frac{U'(C_1)(1+r)}{P_1}\right]$$

$$[2] \quad \left(\frac{1}{1+r}\right) = \beta E\left[\frac{\frac{U'(C_1)}{P_1}}{\frac{U'(C_0)}{P_0}}\right]$$

$$\frac{[1]}{[2]} \quad (1+r) = E\left[\frac{\frac{U'(C_1)(1+i)}{P_1}}{\frac{U'(C_1)}{P_1}}\right]$$

In the more general case involving risk-adverse investors, a covariance term complicates the equilibrium expression. Investors demand a risk premium that depends on the future marginal utility of consumption per dollar. As a result, a higher risk premium is required to compensate lenders for accepting risk when consumption is expected to be highly valued. For example, a recessionary period implies a higher marginal utility per dollar because of a reduced level of income. The resulting

expression is illustrated below. The covariance term represents consumption-based risk, which is conceptually distinct from default risk.

$$(1+r) = 1 + \left(\frac{E(1+i)}{E\left(\frac{U'(C_1)}{P_1}\right)} \right) - \left[\frac{\text{COV}\left(\frac{U'(C_1)}{P_1}, (1+i)\right)}{E\left(\frac{U'(C_1)}{P_1}\right)} \right]$$

The research presented in this paper focuses on the case of risk neutrality. The risk-neutral equilibrium expression which is re-expressed below, forms the basis for the econometric specification employed in section 5.

$$(1+r) = E_0(1+i)$$

The expectations operator suggests that the expected yield is determined by the rational forecasting of the probability of default. Thus, the lender will form his or her expectations based on a probability distribution relating the likelihood of default to the variables that affect default. Following the methodology from Bayoumi *et al*⁸ (1995), the equilibrium condition can be expressed as follows:

$$(1+r) = \rho(H)(1+i) + (1-\rho(H))(0)$$

$$(1+r) = e^{-\rho(H)}(1+i)$$

where $\rho(H)$ is an exponential density function for the probability of *no default*, and H is a vector of determinants affecting default risk. The first-order conditions are given by the following: $\rho' < 0$, the probability of no default

⁸ Bayoumi *et al* (1995) provide a useful methodology for expressing the expected yield of an asset subject to risk in terms of the exponential density function. As a result, we adopt this approach for solving our model.

declines with H ; $\rho(0)=1$, there is no risk if H is a null vector; and $\rho(\infty)=1$, there is certain default if the H vector approaches infinity. An empirical specification can be determined by transforming the equilibrium condition by the natural logarithm, and noting that $\log(1+\alpha) \approx \alpha$, for small values of α .

$$(1+r) = e^{-(H)}(1+i)$$

$$\log(1+r) = \log e^{-(H)} + \log(1+i)$$

$$r = \log(e^{-(X'\beta + \pi D_t + \mu_t)}) + i$$

$$i - r = X'\beta + \pi D_t + \mu_t$$

$$s_t = X'\beta + \pi D_t + \mu_t$$

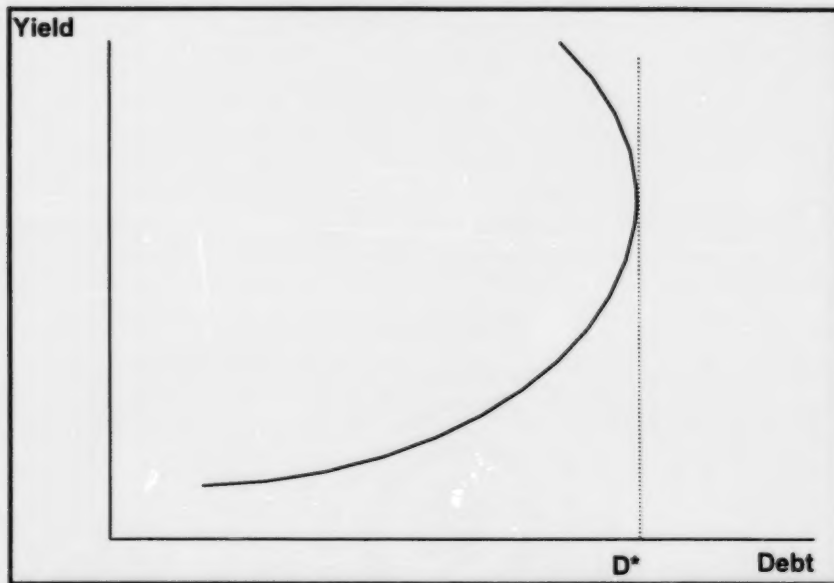
where the risk premium is denoted s_t , the vector of determinants, H , is expanded into a vector of variables X , the debt-to-GDP ratio and a residual error term. Note that β is a vector of parameters and π is the coefficient relating marginal changes in debt to changes in the spread. The model allows for a variety of non-linear functional forms depending on the variables included in the X vector.

The market-discipline hypothesis provides some structure on the variables included in the H vector. The hypothesis suggests that financial markets discipline governments with risk premia reflecting the higher probability of default that results from debt accumulation. Therefore, the rational investor would incorporate the critical fiscal variables that determine the sustainability of a fiscal regime into the H vector, such as the debt- and deficit-to-GDP ratios. Figure 1 illustrates the supply of credit based on the axioms of the market-discipline paradigm.

In Figure 1, the supply curve rises non-linearly until it attains the maximal level of available credit, D^* . Stiglitz and Weiss (1989), and Eaton and Gersovitz (1981) demonstrated that the supply curve may actually exhibit a backward-bending range if the risk premium is related to debt-servicing costs⁹. Alternatively, the risk premium will rise asymptotically once government demand reaches D^* .

⁹ Goldstein and Woglom (1992).

Figure 1
Supply of Credit Under the Market-Discipline Hypothesis



In addition to the key fiscal policy variables, such as the debt- and deficit-to-GDP ratios, the growth rate in GDP should exert a strong influence on the risk premium. Strong nominal GDP growth provides governments with a robust tax base. Consequently, the probability of default should decline for those jurisdictions experiencing growth rates above the national average.

There are a host of other variables that could contribute to the explanatory power of the risk premium. For example, the dependency ratio, which expresses federal cash transfers as a proportion of total revenues, measures provincial vulnerability in meeting its financial obligations in the event of federal transfer restraints. The income-gearing ratio, which expresses debt-servicing charges as a proportion of total revenue, is another potential indicator of unsustainable borrowing. Unfortunately, these ratios tend to exhibit few innovations in the data-generating process, thereby limiting their usefulness as explanatory variables. Further, the relatively small number of observations available from annual provincial fiscal data requires a parsimonious econometric specification.

Credit rating agencies also provide assessments of default risk. However, it is not clear if these assessments are endogenous responses to existing market sentiment, or provide additional value-added information. Credit ratings change infrequently, and display considerable persistence over time. The econometric techniques used in this paper are not well suited

for discrete data of this kind. A technique based on a truncated residual distribution would be preferable. As a result, credit ratings are not used for the empirical work presented in this study.

Liu and Thakor (1984) proposed a two-step procedure for capturing any additional information inherent to credit ratings. The procedure translates discrete credit ratings into a continuous variable by computing the average yield spread of jurisdictions corresponding to a given risk classification. They regressed the other determinants of default risk on this ratings variable. The resulting "ratings residual" represents the explanatory power of credit ratings not captured by the fiscal regressors. The second step of their procedure is to regress the ratings residual from the first step along with the other fiscal variables on the yield spread. This method lowers the standard error of the regression and absorbs any value-added information from the credit assessments. Critics argue that because the residual is orthogonal to the fiscal variables, the second-step coefficient estimates will not change (Bayoumi *et al.*, 1995). Our position is that the procedure is somewhat arbitrary. Further, the residual from the first step will capture the effects of any omitted variable, not only the effect of credit ratings. Thus, the ratings residual is an upward-biased indicator of the explanatory contribution of credit ratings.

4.0 The Data and Tests of Cointegration

A significant econometric issue for this analysis is identifying the stationarity of the time series, particularly the debt-to-GDP ratio and the yield spread between long-maturity provincial bonds. Although one would typically consider the yield spread to be a stationary process, the results of augmented Dickey-Fuller tests and Phillips-Perron non-parametric tests for unit roots reject the hypothesis of stationarity in the Canadian data.

The fiscal data are reported on a Financial Management Basis (FMS), which allows for a fairly consistent comparison across jurisdictions. In contrast, the Public Accounts data apply an incongruous treatment of the accounting universe and other important financial liabilities such as unfunded pension liabilities. Unfortunately, the FMS data set is not widely disseminated in the financial community and became publicly available only midway through the sample period. However, we feel the benefits of a consistent data set compensates for the limitations of the FMS¹⁰. The fiscal variables are also scaled by the respective provincial GDP figures in order to provide a comparable measure of the public debt and deficit burden.

¹⁰ The FMS data series represent a systematic effort to apply a consistent accounting framework across jurisdictions. Credit-rating agencies and other financial analysts will often adjust the provincial Public Accounts in an attempt to obtain similar figures. As a result, the lack of public disclosure should not constitute a significant bias.

All variables are calculated as the difference between the own-province variable and the respective BC variable. For example, the Ontario debt variable is the difference between the Ontario debt-to-GDP ratio and the BC debt-to-GDP ratio. British Columbia acts as a reference point from which the relative risk premium incurred by the other provinces can be measured. BC was selected as the reference point due to its relatively stable public finances over the sample period and its strong economy. These factors suggest that the risk-premium component of BC's long-term bond yield is stable and low in comparison to the other provinces.

Figure 2 presents graphical illustrations of the principle time series adopted for the supply functions. Panels A through C plot the yield spread against the relative debt-to-GDP ratios for the three supply functions that are estimated in section 5. The correlation between relative debt and the yield spread is clearly visible in all three cases. However, the yield spread in Québec is highly variable from 1966 to 1979. There is also an inexplicably large yield spread between the Nova Scotia and BC bonds from 1976 to 1977. The correlation among the Ontario variables is the strongest of the three cases. Panel D compares the spread between British Columbian and federal yields.

Figure 2
Relative Yield Spreads and Debt-to-GDP Ratios

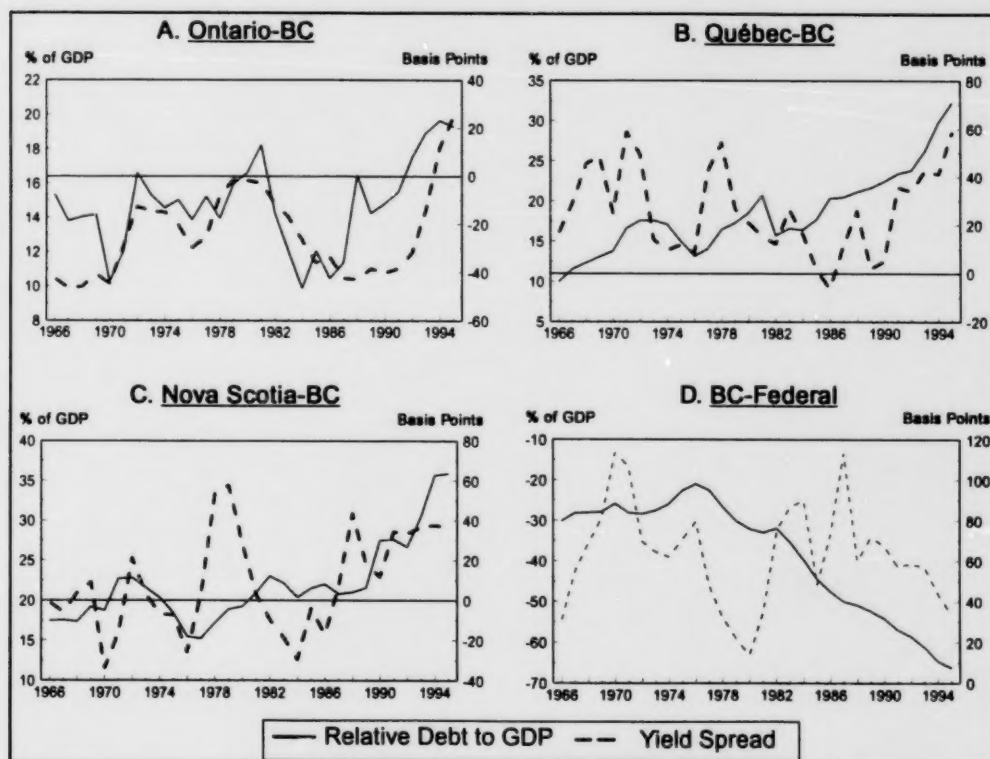


Figure 3 illustrates a simple linear regression line plotted through a scatter diagram relating the yield spreads to relative debt. The dispersion of data points around this regression line varies in each case. The dispersion is fairly tight in the Ontario-BC case, but less strong for Québec and Nova Scotia. The coefficient estimates and R^2 values are summarized in Table 2. Both the Ontario and Nova Scotia regression lines have a slope of .08. Ontario demonstrated the highest R^2 value at .34. In contrast, the results for the Québec case are generally poor, generating a very small R^2 and a slope of .04. The intercepts behave as expected, progressing from 21 basis points in Nova Scotia, 17.3 basis points in Québec and 14 basis points in Ontario.

Figure 3
Scatter Diagrams Relating Yield Spreads to the Net Debt-to-GDP Ratios

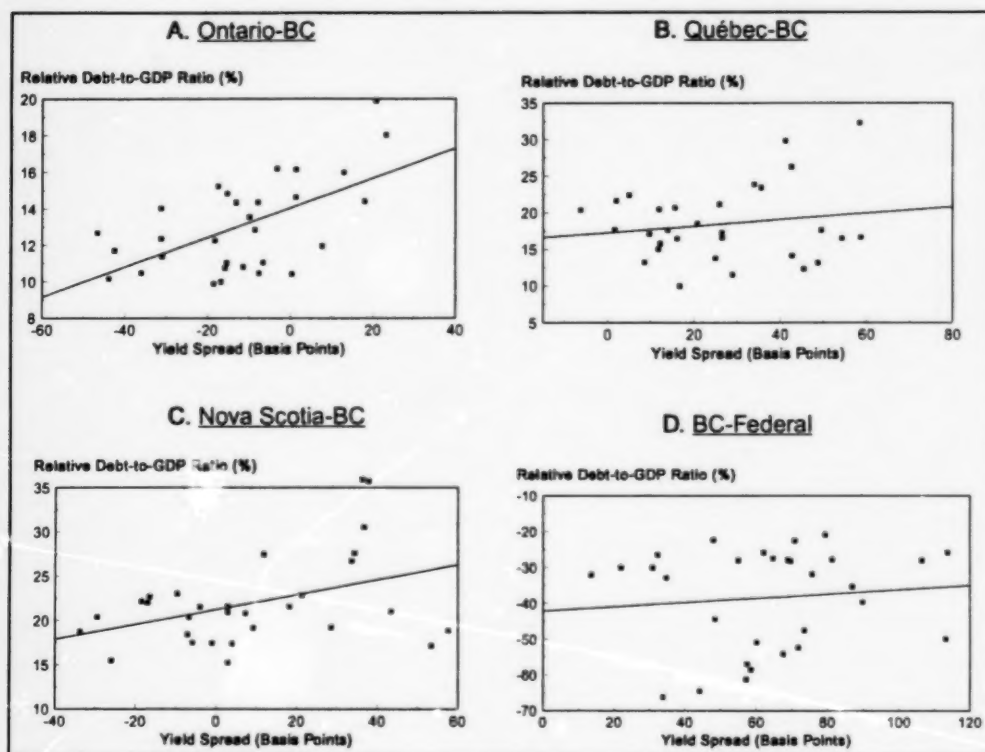


Table 2
Summary of Simple Linear Regression Results: ($y=a+bX$)

	R^2	a	b
Ontario-BC	0.34	14.0	0.08
Québec-BC	0.02	17.3	0.04
Nova Scotia-BC	0.16	21.2	0.08

Appendix A details the results of tests for the order of integration. The augmented Dickey Fuller and the Phillips-Perron non-parametric test for unit roots are used to verify the stationarity of the variables. There is strong evidence indicating that both the yield spreads and the relative debt-to-GDP ratios are non-stationary in each province.

The central hypothesis of this study is that there exists a long-run equilibrium relationship between the yield spread and the relative debt-to-GDP ratio. The cointegration of these variables is a necessary condition for the existence of such a behavioural relationship. As a result, the presence of cointegration between the risk premium and relative debt would provide favourable support for the market-discipline hypothesis.

In addition to the behavioural dimension, cointegration is required to obtain a non-spurious time-series regression. A regression equation containing non-stationary time series is said to be "cointegrated" if the estimation generates a stationary residual. Despite the existence of this relationship, the interpretation of t-statistics for the non-stationary variables remains complicated due to the presence of nuisance parameters in the probability distribution. Therefore, the individual significance of non-stationary variables must be evaluated with caution¹¹.

As a result of these issues, the findings of static cointegration tests are reported in the tables below. The test equation is derived as follows:

$$\begin{aligned}\beta'X_t &= \varepsilon_t \\ \beta_1 S_t + \beta_2 D_t &= \varepsilon_t \\ S_t &= \phi_1 \cdot D_t + \mu_t\end{aligned}$$

$$\text{where: } \phi_1 = \frac{-\beta_2}{\beta_1}; \mu_t = \frac{\varepsilon_t}{\beta_1}$$

¹¹ An excellent reference for macroeconometric issues ranging from cointegration and unit roots, to vector-error correction models, can be found in Alain Paquet's Department of Finance Working Paper No. 94-05 entitled, "A Guide to Applied Modern Macroeconometrics".

and β_1 is normalized to unity. Regressing the above static equation, where S_t represents the yield spread and D_t represents the relative debt-to-GDP ratio, generates a residual series. The stationarity of this residual is summarized in the following table. A constant was also included in the static test equations, however the outcomes were unaffected. The optimal lag for the augmented Dickey Fuller test is determined by selecting a maximum upper bound for the lag length, and iterating the test until the last lag is statistically significant.

The results of these tests, summarized in Table A, provide some support for a cointegration relationship between relative debt and the risk premium. The ADF results support the stationarity of the residuals for the three provinces under certain test specifications. In all three cases, the absence of a constant or trend in the ADF test equation indicates a stationary residual. This specification corresponds to a zero mean and serially uncorrelated OLS error term. However, the results of the Phillips-Perron tests were unsupportive in the Québec and Nova Scotia cases.

Note that the test equation is estimated over a restricted sample range in the Québec case. The restricted period ranges from 1975 to 1996, eliminating the 1965-1974 period which behaves erratically, as can be observed in panel B of Figure 1. The models presented in section 5 will apply the same truncated sample in the Québec case.

Table A
Residual Order of Integration

Test / Specification	Ontario-BC	Québec-BC	Nova Scotia-BC
ADF Test			
Constant	I(1)	I(0)	I(1)
Constant and Trend	I(1)	I(1)	I(1)
Neither	I(0)	I(0)	I(0)
Phillips-Perron Test			
8 Lags			
With Trend	I(1)	I(1)	I(1)
No Trend	I(0)	I(1)	I(1)
2 Lags			
With Trend	I(1)	I(1)	I(1)
No Trend	I(0)	I(1)	I(1)

The static tests were re-estimated to include the other non-stationary variables that are regressed in the empirical models developed in

section 5. The existence of a multivariate cointegration equation which includes the risk premium, the relative-debt-to-GDP ratio, relative GDP growth and the relative deficit-to-GDP ratio is investigated by these tests. The models were also estimated with the inclusion of a linear time trend¹². The test specifications varied by province depending on the stationarity of the regressors. The following regression equations were used for the results reported in Table B:

ONTARIO

$$S_t = K + \beta_1 D_t + \beta_2 DEF_t + \beta_3 \dot{GDP}_t + \beta_4 TREND + \mu_t$$

QUÉBEC

$$S_t = K + \beta_1 D_t + \beta_2 DEF_t + \beta_3 TREND + \mu_t$$

NOVA SCOTIA

$$S_t = K + \beta_1 D_t + \beta_2 \dot{GDP}_t + \beta_4 TREND + \mu_t$$

where $\dot{GDP}$ represents relative nominal GDP growth, DEF is the relative deficit-to-GDP ratio and TREND is a linear time trend.

Table B
Residual Order of Integration

Test / Specification	<u>Ontario-BC</u>		<u>Québec-BC</u>		<u>Nova Scotia-BC</u>	
	No Trend	Trend	No Trend	Trend	No Trend	Trend
ADF Test						
Constant	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)
Constant and Trend	I(1)	I(0)	I(1)	I(1)	I(0)	I(0)
Neither	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)
Phillips-Perron Test						
8 Lags						
With Trend	I(0)	I(0)	I(1)	I(1)	I(1)	I(1)
No Trend	I(0)	I(0)	I(1)	I(1)	I(1)	I(0)
2 Lags						
With Trend	I(0)	I(0)	I(1)	I(1)	I(1)	I(1)
No Trend	I(0)	I(0)	I(1)	I(0)	I(0)	I(0)

¹² The unambiguous stationarity of the Ontario residual under the ADF test depends on the inclusion of the linear trend.

The results are generally more supportive of a cointegration relationship. The outcome of the ADF test equations improved, as highlighted by the gray-shaded areas. When a linear trend is included, cointegration is confirmed in all three cases. However, in the absence of the trend, the results for Ontario continue to identify a unit root in the residual process. This is probably the result of the second-order integrated debt-to-GDP process in Ontario. As discussed in Appendix A, the data-generating process for the relative debt cannot persist as second-order integrated, and is probably the result of a recent spike in Ontario's debt.

However, the outcomes of the two test procedures conflict in the Québec-BC and Nova Scotia-BC cases. Interestingly, the Phillips-Perron results unambiguously support a stationary residual in the Ontario data. The inclusion of the linear trend slightly improved the outcome of the Phillips-Perron results for Québec and Nova Scotia under certain test specifications.

There are several limitations of these tests for unit roots. First, the augmented Dickey-Fuller test is superior to the Phillips-Perron test in small samples, or in cases involving non-normal or heteroskedastic errors. The Phillips-Perron test outperforms the ADF tests in large samples or in the event of autocorrelated errors. Both tests reject the hypothesis of unit roots too often if the data follows an IMA process with a negative coefficient. (Alain Paquet 1994, p. 3-46).

5.0 Empirical Methodology and Results

The empirical models presented in this section entail a balance between a parsimonious econometric specification and the risk of omitted variable bias. Unfortunately, this balance is required because the fiscal data are only available at an annual frequency, resulting in a small sample. Consequently, the principle regressors are the relative debt- and deficit-to-GDP ratios and the relative growth in nominal GDP. The objective is to capture the long-run relationship between the risk premium and public debt, rather than to estimate a behavioural model of the short-run variation in the yield spread. As a result, only the variables most likely to explain long-run effects are included in the regression equation.

Several models were estimated to determine the risk premium on Ontario, Québec and Nova Scotia bond yields relative to that of BC. The four principle models that were estimated are outlined as follows:

Linear Model:

$$S_t = K + \sum_{i=1}^n \beta_i DUM_i + X'_t \alpha + \pi D_t + \mu_t$$

Non-linear Model A:

$$S_t = K + \sum_{i=1}^n \beta_i DUM_i + X'_t \alpha + \pi (D_t)^2 +$$

Non-linear Model B:

$$S_t = K + \sum_{i=1}^n \beta_i DUM_i + X'_t \alpha + \pi (D_{(j,t)}^2 - D_{(BC,t)}^2) +$$

where $j = (\text{Ontario, Québec, Nova Scotia})$

The Bayoumi-Goldstein-Woglom (BGW) Specification:

$$S_t = K + \sum_{i=1}^n \beta_i DUM_i + \frac{(X'_t \alpha + (\pi + \delta r) D_t)}{(1 - \delta D_t)}$$

where S_t represents the yield spread, D_t is the relative debt-to-GDP ratio, $(D_t)^2$ is the relative debt-to-GDP ratio squared, $[(D_{j,t})^2 - (D_{BC,t})^2]$ is an alternative non-linear definition for net debt, X_t is a vector of variables which includes the relative deficit and nominal GDP growth, and DUM_j are dummy variables to account for inexplicably large yield spreads. Note that the non-linearity defined by $[(D_{j,t})^2 - (D_{BC,t})^2]$ requires that a zero replace negative values of BC debt (accumulated surpluses) in order to prevent artificially depressing the relative debt burden of province j . The BGW specification is interesting because it models the non-linearity through debt-servicing costs. The BGW specification also nests the linear model if δ is found to be statistically insignificant.

The results from each model were subjected to a battery of econometric tests. The error terms are tested for stationarity in order to confirm both that a non-spurious regression equation has been attained, and to test for a cointegration relationship. The residuals are examined for high-order serial correlation using both the q -statistic and the LM-test procedure. These tests are used in conjunction with the d -statistic, which can identify the presence of first-order serial correlation. In addition to these tests, the normality of the residual distribution is verified with the Jarque-Bera statistic. Finally, the RESET test is also applied to the results of every

model. The alternative hypothesis of this test is that the estimates are biased as a result of specification errors which could include omitted variables, simultaneity bias or improper functional form. Finally, the stability of the parameters are verified with rolling coefficient estimates. This approach assists the detection of possible structural breaks in the data-generating process.

The following three sections report the estimation output for the three provincial supply functions. In all cases except Québec, the results were rigorous to the tests just described. The interested reader is directed to Appendix B which presents the detailed results of the above tests. The regression output for the linear and two non-linear models (A and B) are reported, however, the findings from the BGW regression specification were not revealing for any province and are therefore not presented. Due to the non-stationarity of several time series in this analysis, caution should be exercised in the interpretation of t-statistics and marginal significance values. The empirical results are reported in three stages. First, the OLS estimates are reported before accounting for the possibility of a simultaneity bias. Second, the findings of Granger-causality tests are discussed. The outcome of these tests will indicate if the yield spread Granger causes the relative debt ratio. If the demand for debt is sensitive to the yield spread, then one would expect to find a Granger-causality relationship. Finally, the estimates from a two-stage least squares procedure are reported.

5.1 The Relative Ontario-BC Supply of Credit

Table 3 highlights the estimates for the relative Ontario-BC equations. The p-values indicate that all three models are significant by a wide margin. With the exception of the relative deficit, all coefficient estimates are highly significant. The linear model indicates that the risk premium increases by 2.57 basis points for every one-percentage point change in the relative debt-to-GDP ratio. A one-percentage point increase in Ontario's nominal GDP growth over that of BC lowers the yield spread by 2.93 basis points.

The non-linear Ontario-BC models also indicate a statistically significant relationship between debt and yield spreads. Due to the presence of nuisance parameters, the statistical superiority of one model over the other is not examined because the resulting test statistic would be invalid. However, model B possesses a superior p-value, adjusted R^2 , d-statistic and lower standard error. As a result, it is favoured over the results from non-linear model A. The relative deficit was not a significant explanatory variable in any of the three models. However, its marginal significance is minimized at .18 in model B. Lagged values of the deficit ratio also failed to yield statistically significant estimates.

As reported in Table 4, the risk premium increases in a non-linear fashion. The coefficient estimate of 0.05 indicates that for every unit difference of the debt-to-GDP ratios squared, the risk premium will increase by .05 basis points. For example, at the observed relative debt-to-GDP ratio in 1980 of 10.3 percent, the risk premium was 5.3 basis points. However, the yield spread increases by 1 basis point following less than a one percentage-point increase in relative debt in 1990. Cases 1 and 2 present hypothetical debt-to-GDP levels in order to illustrate the extent of the non-linearity. If the debt-to-GDP ratio increases from 30 to 50 percent, then the risk premium rises sharply from 105 to 225 basis points.

Cointegration was verified by testing the residual with the augmented Dickey-Fuller and Phillips-Perron tests for unit roots. These tests confirmed that the regressions generated a stationary residual. The estimation results were also rigorous to the other specification tests already discussed (Appendix B, Table B3).

Several issues arise from the results presented below. First, the intercept is negative and large in absolute value, which implies that Ontario yields tend to be significantly lower than BC long-term yields, *ceteris paribus*. The absolute value of the constant declines as the specification becomes increasingly non-linear. Thus, the negative constant may be compensating for a specification that is insufficiently non-linear. The presence of cointegration attests to the existence of a long-run common stochastic trend between the risk premium and the relative debt-to-GDP ratio. This fact is interesting in itself because it is a necessary condition for a behavioural relationship between the market's perception of risk and fiscal policy.

The sign and magnitude of the constant in the cointegration equation may be affecting the reduced-form estimate of the constant in these models. The estimated constant in the Ontario static cointegration equation is -49.8, with a p-value of .007. Therefore, the long-run equilibrium is characterized by higher yields in BC relative to Ontario, *ceteris paribus*.

Table 3
Ontario-BC Results
 (p-values in parentheses)

Statistic / Test Result	Linear Model	Non-linear Model A (D_t) ²	Non-linear Model B [(D_{jt}) ² - ($D_{BC,t}$) ²]
Constant	-50.2 (.002)	-33.7 (0.0)	-27.7 (0.0)
Relative Debt:GDP	2.57 (.04)	0.1 (.028)	0.05 (.001)
Relative Deficit:GDP	0.95 (.78)	0.84 (.8)	3.51 (.18)
Relative GDP Growth	-2.93 (.01)	-2.9 (.007)	-2.97 (.002)
Adjusted R ²	0.53	0.55	0.64
Standard Error of Regression	12.9	12.65	11.3
d-statistic	1.53	1.58	2.13
Joint Test of Significance, p-value	0.00006	0.00004	0.000002

Table 4
Ontario-BC Non-linear Model B Results
Non-linearity of Risk Premium

Date	Ontario Debt- to-GDP Ratio (%)	BC Debt-to- GDP Ratio (%)	Relative Debt- to-GDP Ratio (%)	Estimated Risk Premium (basis pts.)
1970	4.38	0.0	4.38	.96
1980	10.25	0.0	10.25	5.25
1990	11.18	0.004	11.18	6.25
Case 1	50.0	20.0	30.0	105
Case 2	70.0	20.0	50.0	225

The results of Granger causality tests are outlined in Table 5. The tests incorporated a lag order of one or two, which should be sufficient to address possible serial correlation problems in annual data. The evidence does provide some evidence of a Granger relationship. The yield spread predicts future innovations in the relative debt-to-GDP ratio if one lag is applied in the test specification.

Granger causality results are important indicators of potential simultaneity problems. If the demand for credit is sensitive to the risk premium, then one would expect that lagged innovations in the spread would predict corresponding changes in the level of debt. If the demand for credit is dependent on the yield spread, then the regressors in the supply equation will be correlated with the error term. In this case, the resulting estimates would be biased and inconsistent.

Table 5
Ontario-BC Granger Causality Results

Granger Equation	Lag (p)	Null Hypothesis $H_0 : \alpha_i = 0, i \geq (1, p)$	Result
$D_t = k + \sum \beta_i D_{t-i} + \sum \alpha_i S_{t-j} + \varepsilon_t$	1	Spread does not Granger cause Debt	$f = 4.31$ $p = 0.05$
	2	Spread does not Granger cause Debt	$f = 0.78$ $p = 0.47$
$S_t = k + \sum \beta_i S_{t-i} + \sum \alpha_i D_{t-j} + \varepsilon_t$	1	Debt does not Granger cause Spread	$f = 0.02$ $p = 0.38$
	2	Debt does not Granger cause Spread	$f = 1.58$ $p = 0.23$

The results presented above indicate that the level of debt could be simultaneously determined because the spread predicts future relative debt ratios. However, simple correlations between the regressors and the resulting residuals from the previous empirical models failed to generate a correlation, which suggests simultaneity is not a significant problem. Nevertheless, the results of a two-stage least squares procedure are detailed in Table 6 for non-linear model B.

Table 6
Ontario-BC Results of the Instrumental Variables Estimation
 (p-values in parentheses)

Variable	OLS	Set A	Set B	Set C	Set D	Set E
Constant	-27.7 (0.0)	-26.0 (.0003)	-31.4 (0.0)	-33.7 (0.0)	-26.1 (.001)	-25.2 (.0001)
Relative GDP Growth	-2.97 (.002)	-4.16 (.004)	-2.63 (.03)	-1.9 (.19)	-3.98 (.02)	-3.78 (.001)
Relative Deficit to GDP	3.51 (.18)	.99 (.8)	5.61 (.1)	7.95 (.07)	1.48 (.77)	2.02 (.5)
Relative Debt to GDP, squared	0.05 (.001)	.06 (.008)	.06 (.005)	.05 (.002)	.05 (.001)	.05 (.01)
Adjusted R ²	0.64	.56	.59	.59	.62	.68
Standard Error of Regression	11.3	11.9	11.6	12.0	11.6	10.4
d-statistic	2.13	2.35	2.11	1.93	2.32	2.38
<u>GIVE Residual:</u>						
I(d)	—	I(0)	I(0)	I(0)	I(0)	I(0)
Joint Coefficient f-test	—	.42 (.52)	1.17 (.29)	4.49 (.04)	.16 (.69)	.36 (.56)
Adjusted R ²	—	0.0	0.0	0.0	0.0	0.0

The optimal choice of instruments requires a correlation with the innovations in the demand for debt, but not the supply of debt. Unfortunately, investors are assumed to understand the factors affecting the demand for credit. As a result, the task of finding the appropriate instruments is rendered particularly difficult. Further, instrumental variable estimation is based on asymptotic consistency, which may bias the results for this relatively small sample. The set of instruments are applied consistently for each province. Five different sets, each varying slightly, were used in order to observe the sensitivity of the estimates to the choice of instruments.

The five sets of instruments are modifications to a baseline set. The initial case, denoted set A, contains the following instruments: the lagged

relative program spending-to-GDP ratio, the lagged relative dependency ratio, the Canada-US exchange rate and its first lag, the lag of the federal funds rate, the lag of the yield spread, the relative unemployment rate and the lag of real Ontario GDP. The other sets are minor variations of the baseline case by excluding those instruments which exert the greatest impact on the point estimates. The composition of sets B to E are as follows: the lag of the US 91-day T-Bill rate is included in set B, the Canada-US exchange rate is excluded in set C, both the exchange rate and the US T-Bill rate are excluded from set D, and set E is equivalent to the baseline case except demographic variables are incorporated. The demographic variables are the number of persons aged 24 and under, and the population aged 65 and over. These variables should be closely related to the largest pressures on government program spending, such as health and education. The demographic instruments are available beginning only from 1970, which reduces the sample by 4 observations.

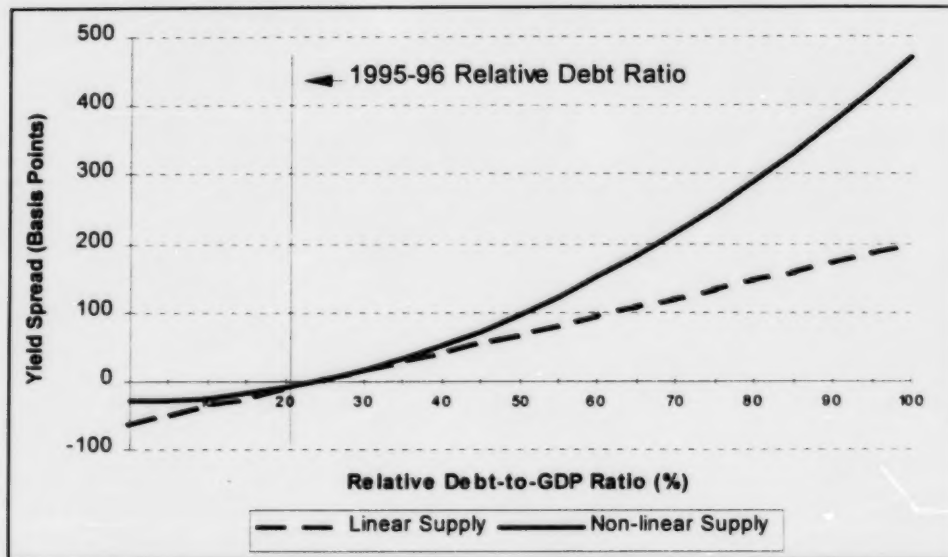
In general, the relative debt-to-GDP coefficients generated under the five sets of instruments were virtually unchanged from the OLS estimates. The relative deficit and GDP growth variables exhibited a much greater dependence on the choice of instruments. The deficit variable ranged from a sharp 5.6-basis-point effect on the yield spread that is significant at the 10 percent level, to just .99 basis points. Despite this result, the non-linearity of the supply function with respect to the debt-to-GDP variable continues to be supported by the estimates.

The explanatory variables are also regressed on the two-stage least squares residual. The resulting adjusted R^2 and joint test of significance of the parameters (excluding the constant) are reported in Table 6 under the section identified as GIVE Residual. In all cases excluding instrument set C, the error term is uncorrelated with the explanatory variables, decreasing the risk of a simultaneity bias. In the case of set C, the correlation between the regressors and the residual invalidates the coefficient estimates.

The square relative debt coefficient is consistently within 0.01 of the OLS estimate of 0.05. The inclusion of the US T-bill rate seems to affect the relative deficit estimate most strongly. The results under set B generates a point estimate of 5.6, compared to .99 in the baseline case. The demographic instruments in set E produced a stronger relative GDP effect, however the squared debt term remained at 0.05. In all cases, the estimated constant was within a relatively narrow range.

Figure 4 illustrates the linear and non-linear supply functions assuming a constant debt-to-GDP ratio in BC of 5 percent. The impact on the yield spread from the non-linearity of the supply relationship is most striking at quite high levels of relative debt. The steepening slope provides strong support for the market-discipline paradigm. However, the risk premium is relatively small at current debt levels.

Figure 1
Ontario-BC Relative Supply of Credit



5.2 The Relative Nova Scotia-BC Supply of Credit

The results for the Nova Scotia-BC linear and non-linear models are similar to the findings for the Ontario-BC case. Table 7 highlights the coefficient estimates, marginal significance values and other general statistics.

The results of the linear model are comparable to the previous case. An additional percentage point in relative debt causes an increase of 2.15 basis points in the yield spread. The relative deficit variable is insignificant and small in magnitude. In contrast, an increase of one percentage point in relative GDP growth causes the yield spread to fall by 1.74 basis points. Two dummy variables are included in the specification to account for inexplicably large yield spreads in 1976 and 1977. Both dummies are highly significant.

Table 7
Nova Scotia-BC Results
(p-values in parentheses)

Statistic / Test Result	Linear Model	Non-linear Model A (D_L) ²	Non-linear Model B [(D_L) ² - (D_{BC}) ²]
Constant	-45.0 (.002)	-18.9 (.03)	-12.1 (.08)
Dummy 1	55.9 (.004)	60.9 (.002)	52.7 (.005)
Dummy 2	62.6 (.001)	53.4 (.005)	61.7 (.001)
Relative Debt:GDP	2.15 (.001)	0.04 (.001)	0.03 (.001)
Relative Deficit:GDP	0.39 (.88)	0.95 (.7)	1.49 (.54)
Relative GDP Growth	-1.74 (.001)	-1.7 (.01)	-1.79 (.008)
Adjusted R ²	0.58	0.56	0.6
Standard Error of Regression	16.3	16.6	16.0
d-statistic	1.68	1.63	1.84
Joint Test of Significance, p-value	0.00007	0.0001	0.00006

The general statistical properties of the non-linear specifications provide strong support for a non-linear supply function. As with the Ontario-BC case, non-linear model B produced a lower standard error, lower p-value and a higher d-statistic and adjusted R². The risk premium rises non-linearly with the relative debt-to-GDP ratio. Table 8 summarizes the impact of rising relative debt on the yield spread.

As with the Ontario-BC results, the non-linear rise in yield spreads with respect to an increase in relative debt is quite evident. Interestingly, the Nova Scotia-BC point estimate for the relative debt is not greater than the Ontario-BC estimate (.03 compared to .05 in Ontario). Theory suggests that Ontario should benefit from its large and diversified economic base to incur a smaller risk premium for additional increments in debt. This may

Table 8
Nova Scotia-BC Model B
Non-linearity of the Risk Premium

Date	Nova Scotia Debt-to-GDP Ratio (%)	BC Debt-to- GDP Ratio (%)	Relative Debt- to-GDP Ratio (%)	Estimated Risk Premium (b.p.)
1970	12.97	0.0	12.97	5.05
1980	13.33	0.0	13.33	5.33
1990	28.42	0.01	28.41	24.23
Case 1	50.0	20.0	30.0	63.0
Case 2	70.0	20.0	50.0	135.0

indicate that the volume of borrowing, in addition to the debt-to-GDP level, affects the risk premium. However, attempts to identify a "quantity effect" were unsuccessful.

Another possible explanation for the smaller effect of fiscal policy in Nova Scotia compared to Ontario is the market's perception that the federal government would bail-out smaller provinces in the event that they cannot meet their financial obligations. Thus, a smaller province may benefit from a favourable externality whereby in the event of a default, the costs of the debt are spread over all Canadian taxpayers. This externality thereby reduces the risk of investing in long-maturity provincial bonds. In contrast, a bail-out of a larger province, such as Ontario, is probably not financially feasible for the federal government¹³.

As in the previous Ontario case, the intercept is negative and large in absolute value. The intercept becomes less negative as the specification becomes increasingly non-linear, suggesting that the intercept is reflecting the non-linearity of the relationship. However, the negative intercept may also reflect the external benefit accruing to Nova Scotia due to the market's perception that the federal government would bail-out smaller provinces.

¹³ On a Public Accounts basis, net debt in Ontario for 1994-95 amounts to 16.2 percent of the net federal debt compared to 3.4 percent for Nova Scotia net debt.

The stationarity of the residual supports the existence of a cointegration relationship among the non-stationary variables. This satisfies a necessary condition for a long-run equilibrium relationship between the risk premium, the relative stock of public debt and relative GDP growth. The extent of the non-linearity is illustrated in Table 8. The estimated risk premium increased by approximately 19 basis points from the observed debt-to-GDP values between 1980 and 1990. Case 1 and case 2 present hypothetical extrapolations based on the estimates obtained from the data. An increase in relative debt from 30 to 50 percentage points, would increase the yield spread from 63 to 135 basis points.

The results of Granger causality tests are summarized in Table 9. The outcome of the tests did not indicate that the spread Granger causes the relative debt ratio, or that the relative debt Granger causes the yield spread. As a result, a simultaneity bias should not represent a significant problem.

Table 9
Nova Scotia-BC Granger Causality Results

Granger Equation	Lag	Null Hypothesis $H_0 : \alpha_i = 0, i \geq (1, p)$	Result
$D_t = k + \sum \beta_i D_{t-i} + \sum \alpha_i S_{t-i} + \varepsilon_t$	1	Spread does not Granger cause Debt	$f = 1.43$ $p = 0.24$
	2	Spread does not Granger cause Debt	$f = 2.23$ $p = 0.13$
$S_t = k + \sum \beta_i S_{t-i} + \sum \alpha_i D_{t-i} + \varepsilon_t$	1	Debt does not Granger cause Spread	$f = 0.24$ $p = 0.63$
	2	Debt does not Granger cause Spread	$f = 0.36$ $p = 0.70$

The results of the two-stage least squares estimation are outlined in Table 10. The sets of instruments are identical to those applied in the Ontario-BC case. The coefficient estimate for the relative debt-to-GDP variable was statistically significant and equivalent to the OLS estimate in each estimation. This provides additional support for the unbiasedness of the OLS estimates. For each set of instruments, the GIVE residuals are uncorrelated with the explanatory variables and follow a stationary process.

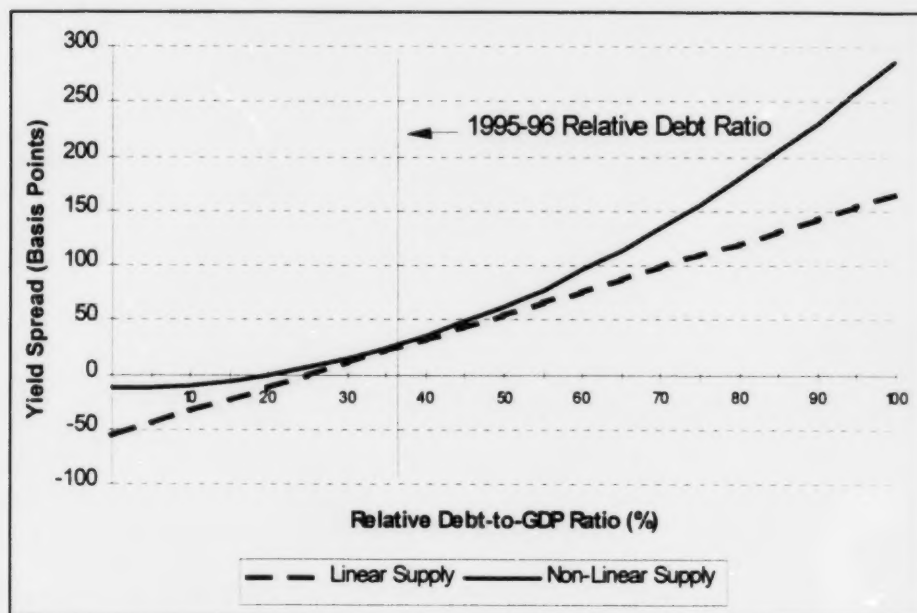
Table 10
Nova Scotia-BC Results of the Instrumental Variables Estimation
 (p-values in parentheses)

Variable	OLS	Set A	Set B	Set C	Set D	Set E
Constant	-12.1 (.08)	-14.6 (.16)	-11.1 (.26)	-14.5 (.15)	-15.3 (.14)	-15.8 (.05)
Relative GDP Growth	-1.79 (.008)	-2.66 (.008)	2.02 (.02)	-1.95 (.02)	-2.43 (.01)	-1.96 (.01)
Relative Deficit to GDP	1.49 (.54)	-1.46 (.72)	.02 (.99)	1.62 (.67)	2.1 (.6)	2.63 (.35)
Relative Debt to GDP, squared	.03 (.001)	.03 (.002)	.03 (.001)	.03 (.0005)	.03 (.001)	.03 (.0007)
Adjusted R ²	.60	.55	.58	.59	.57	.60
Standard Error of Regression	16.0	16.8	16.3	16.2	16.5	16.1
d-statistic	1.84	1.89	1.93	1.86	1.89	1.86
<u>GIVE Residual:</u>						
I(d)	—	I(0)	I(0)	I(0)	I(0)	I(0)
Joint Coefficient f-test	—	.28 (.6)	.003 (.95)	.22 (.64)	.45 (.51)	1.07 (.31)
Adjusted R ²	—	0.0	0.0	0.0	0.0	0.0

The relative deficit variable remained statistically insignificant under each set of instruments. The magnitude of the deficit point estimate fluctuated depending on the inclusion of the Canada-US exchange rate and the US T-Bill yield. In contrast, the impact of relative GDP growth on the spread is significant at the five percent level in each case. The point estimates derived by OLS and the set A, set C and set E instruments are within a narrow band, ranging from -1.79 to -1.96. The demographic instruments generated estimates that are quite similar to the baseline case. However, the standard error of the regression and the R² value both demonstrated an improvement compared to the baseline instruments.

Figure 5 depicts the linear and non-linear supply functions assuming a constant debt-to-GDP ratio in BC of 5 percent. The slope is not as great as in the Ontario-BC case. The most interesting observation is that the risk premium is relatively small for observed levels of relative debt. Only very large differences from current debt levels will generate rising yield spreads.

Figure 5
Nova Scotia-BC Relative Supply of Credit



5.3 The Relative Québec-BC Supply of Credit

Finally, the Québec-BC results are reported below for the principle three models. Of the three provinces, the risk premium for Québec is perhaps the most difficult to represent econometrically as a result of the political uncertainty surrounding its long-term debt issues. Unfortunately, the political component of the risk premium is difficult to isolate from the default risk. Further, if this component of the risk premium is significant, then the quality of the models estimated in this study will deteriorate accordingly.

Empirical results improved substantially by restricting the sample range to the 1975 -1996 period. In addition, two dummy variables were used to account for the political uncertainty that affected the spread in the 1976-77 and 1977-78 fiscal years. Table 11 reports the estimation output from the three primary models.

Table 11
Québec-BC Results
1975-96 Sample Range
(p-values in parentheses)

Statistic / Test Result	Linear Model	Non-linear Model A $(D_t)^2$	Non-linear Model B^{14} $[(D_{J,t})^2 - (D_{BC,t})^2]$
Constant	-14.5 (.1)	6.17 (.19)	11.8 (.01)
Dummy for 1976-77	63.7 (.0001)	61.7 (.0001)	58.9 (.0001)
Dummy for 1977-78	57.2 (.0001)	57.2 (0.0)	55.8 (0.0)
Relative Debt:GDP	2.01 (.001)	0.05 (.0005)	0.02 (.001)
Relative Deficit:GDP	-4.39 (.14)	-4.18 (.12)	-1.79 (.46)
Relative GDP Growth	-1.81 (.08)	-1.65 (.09)	-1.92 (.03)
AR(p) Coefficient	AR(6), p=.005	AR(6), p=.003	AR(6), p=.002
Adjusted R2	0.67	0.71	0.68
Standard Error of the Regression	10.6	9.87	10.2
Joint Test of Significance, p-value	0.0005	0.0002	0.0001

¹⁴ The RESET test indicated econometric problems following the correction for high-order serial correlation.

The LM serial correlation test and tests for high-order autocorrelation among the residuals indicated a serial correlation problem of 6 or more lags. An AR(6) transformation was performed in order to obtain efficient estimates. Following the transformation, results improved dramatically. The linear model point estimate for the effect on the risk premium from an percentage-point change in the relative debt-to-GDP ratio was in the same range as the Ontario and Nova Scotia estimates at 2.01 basis points. Unfortunately, the coefficient for the relative deficit-to-GDP ratio assumed a negative value, but was statistically insignificant.

Estimates from the two non-linear models were also comparable to the Ontario and BC results following the AR(6) transformation. Unfortunately, the RESET test indicates the presence of general specification problems in non-linear model B following the correction for serial correlation. As a result, the estimation output from non-linear model A is favoured in the Québec-BC case. In both models, the relative deficit estimates continued to be insignificant and retained a negative sign. The intercept is positive for the two non-linear regressions in contrast to the prior two cases, however it is statistically insignificant. The estimated constant in the static cointegration equation was -9.76 with a p-value of .49.

Table 12 highlights the non-linear relationship between the risk premium and the relative stock of debt to GDP, based on the results of model B. As before, case 1 and 2 represent hypothetical scenarios for the risk premium based on the coefficient estimates.

Table 12
Québec-BC
Non-linearity of the Risk Premium

Date	Québec Debt-to-GDP Ratio (%)	BC Debt-to-GDP Ratio (%)	Relative Debt-to-GDP Ratio (%)	Estimated Risk Premium (b.p.)
1975	7.4	-7.6	15.0	11.3
1985	19.1	1.5	15.6	15.5
1995	38.1	5.8	32.2	52.2
Case 1	50.0	20.0	30.0	42.0
Case 2	70.0	20.0	50.0	90.0

The results of Granger tests did not support the contention that the spread Granger causes relative debt, or *vice versa*. Table 13 details the results of the tests. As in the Nova Scotia-BC case, the lack of a Granger causality relationship implies that lagged innovations in the spread do not predict the demand for credit. Despite this evidence, the estimates from a two-stage least squares procedure are outlined in Table 14.

Table 13
Québec-BC Granger Causality Results

Granger Equation	Lag	Null Hypothesis $H_0 : \alpha_i = 0, i \in (1, p)$	Result
$D_t = k + \sum \beta_i D_{t-i} + \sum \alpha_i S_{t-j} + \varepsilon_t$	1	Spread does not Granger cause Debt	$f = 1.68$ $p = 0.21$
	2	Spread does not Granger cause Debt	$f = 0.93$ $p = 0.41$
$S_t = k + \sum \beta_i S_{t-i} + \sum \alpha_i D_{t-j} + \varepsilon_t$	1	Debt does not Granger cause Spread	$f = 1.0$ $p = 0.33$
	2	Debt does not Granger cause Spread	$f = 1.18$ $p = 0.33$

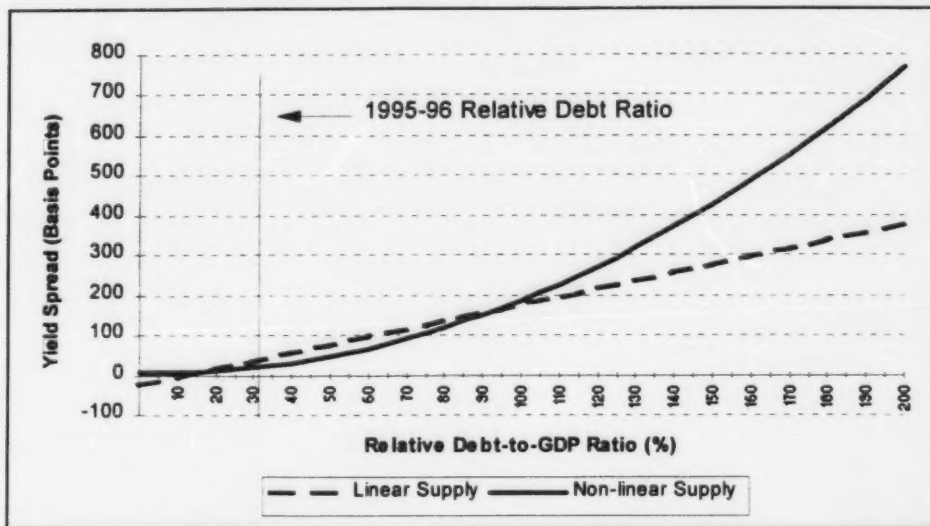
The instruments were selected from the identical sets as those used for the Ontario and Nova Scotia estimations. However, the GIVE estimates are presented for non-linear model A because the RESET test illustrated specification errors under model B. The squared debt coefficient estimate was within a very narrow range of .04 to .05 confirming the non-linearity of the supply function after accounting for the possibility of a simultaneity bias. The relative deficit coefficient posed a problem because it adopted a negative sign and is statistically different from zero at the 10 percent level. The point estimate for relative GDP growth is also within a consistent range of the OLS estimate.

Table 14
Québec-BC Results of the Instrumental Variables Estimation
 (p-values in parentheses)

Variable	OLS	Set A	Set B	Set C	Set D	Set E
Constant	6.17 (.19)	9.75 (.16)	10.5 (.12)	7.36 (.21)	7.9 (.15)	11.23 (.09)
Relative GDP Growth	-1.65 (.09)	-2.91 (.02)	-2.67 (.04)	-2.76 (.04)	-2.63 (.04)	-2.23 (.06)
Relative Deficit to GDP	-4.18 (.12)	-6.26 (.06)	-6.88 (.05)	-6.79 (0.07)	-6.78 (.04)	-6.57 (.04)
Relative Debt to GDP, squared	.05 (.0005)	.04 (.007)	.04 (.008)	.05 (.002)	.05 (.001)	.04 (.008)
Adjusted R ²	.71	.56	.59	.64	.65	.61
Standard Error of Regression	9.87	10.5	10.5	10.8	10.6	10.2
d-statistic	—	2.64	2.65	2.48	2.48	2.51
<u>GIVE Residual:</u>						
I(d)	—	I(0)	I(0)	I(0)	I(0)	I(0)
Joint Coefficient f-test	—	.005 (.94)	.14 (.71)	.17 (.68)	.14 (.72)	.07 (.79)
Adjusted R ²	—	0.0	0.0	0.0	0.0	0.0

Figure 6 illustrates the linear and non-linear supply functions. Non-linear model A is plotted rather than model B which is favoured for the Ontario and Nova Scotia models. This follows concerns arising from the RESET test regarding non-linear specification B after adjusting for serial correlation problems. The non-linearity is not as strong as in Nova Scotia or Ontario. Interestingly, the non-linear supply curve intersects the linear supply function twice. After the debt ratios diverge by approximately 70 percentage points, the yield spread begins increasing at an accelerating pace.

Figure 6
Québec-BC Relative Supply of Credit (non-linear model A)



6.0 Conclusion

The focus of this study has been to identify a systematic relationship between the risk premium on government bonds and the behaviour of fiscal policy among a sample of four Canadian provinces. The presence of cointegration in each model suggests a long-run equilibrium relationship between the yield spread and the debt-to-GDP ratio. The parameter estimates relating the effect on the yield spread from a percentage-point change in the relative debt ratio also provides a tight range of point estimates. The linear models generated estimates ranging from 2.0 to 2.6 basis points. The non-linear specifications produced comparable coefficient estimates in each of the three provinces. The impact of a unit change in the difference of the squared debt-to-GDP ratios ranged from .03 to .05. The yield curve begins increasing rapidly in the non-linear specifications compared to the linear models once the debt-to-GDP ratios diverge by significant magnitudes¹⁵. This provides strong support for the market-based fiscal discipline hypothesis.

The results of the instrumental variable procedures demonstrated that the OLS coefficient estimates are fairly robust with respect to the non-linearity in relative debt. The choice of instruments remains a problematic issue, particularly under the assumption of rational expectations. Investors are assumed to understand the variables that affect the risk of default, and therefore adjust the supply of credit accordingly for innovations that

¹⁵ Observing the linear and non-linear supply functions in Figures 4 through 6 highlights this observation. As the relative debt ratios exceed 35 to 50 percentage points, the yield spread begins to increase rapidly compared to the linear supply functions.

primarily affect demand. The robustness of the estimates illustrates that the demand for credit is not highly elastic with respect to the yield spread. The results of Granger causality tests reinforce this conclusion

Several issues remain unresolved. The results for the Québec-BC case are generally unsatisfactory, particularly given that a truncated sample is required to obtain meaningful results. Another puzzle is the apparent statistical insignificance of the contemporaneous and lagged relative deficit-to-GDP ratios for each province. Finally, it is curious that the effect on the yield spread from a change in the debt-to-GDP ratio is strongest in Ontario and weakest in Nova Scotia. Similarly, the negative constant in the Nova Scotia-BC case is paradoxical because one would expect that BC, with its larger economic base and more stable financial situation would experience lower yields than Nova Scotia. This might be explained by a view held in financial markets that the federal government would bail out smaller provinces if they cannot meet their financial obligations.

Overall, the analysis presented in this paper has demonstrated a clear relationship between fiscal policy and the market's evaluation of risk. Further, given the shape of the estimated non-linear supply functions, significant increases in the risk premium do not become problematic until provincial debt-to-GDP ratios diverge significantly from their current levels. However, since most provinces project either a surplus, balanced budget or have a fiscal plan to eliminate budgetary imbalances, the likelihood of developing such large yield spreads seems unlikely in the near future.



Appendix A: Unit Root Tests

Summary Table A1 reports the order of integration for all the variables. Detailed test statistics and results for each variable are presented later in the Appendix. The ADF test and the Phillips-Perron test were used to evaluate the stationarity properties of each variable.

Table A1

Variable	ADF Result	Phillips-Perron Result	I(d) for Paper
<u>Ontario-BC:</u>			
Spread	I(1)	I(1)	I(1)
Relative Debt (level)	I(2)	I(2)	I(2) ¹⁶
Relative Deficit	I(1)	I(1)	I(1)
Relative GDP Growth	I(1)	I(1)	I(1)
<u>Québec-BC:</u>			
Spread	I(1)	I(1)	I(1)
Relative Debt (level)	I(1)	I(1)	I(1)
Relative Deficit	I(1)	I(1)	I(1)
Relative GDP Growth	I(0)	I(0)	I(0)
<u>Nova Scotia-BC:</u>			
Spread	I(1)	I(1)	I(1)
Relative Debt (level)	I(1)	I(1)	I(1)
Relative Deficit	I(0)	I(0)	I(0)
Relative GDP Growth	I(1)	I(1)	I(1)

The results for the non-linear debt-to-GDP variables are summarized in Table A2. An important issue arising from these results is the treatment of second order integrated variables. The empirical analysis for this study has assumed that the Ontario debt-to-GDP ratio is first-order integrated because relative debt cannot persist as an I(2) process. The large increase in Ontario's relative debt in the early 1990s is interpreted as a transitory aberration, rather than a reflection of the underlying data generating process.

¹⁶ It seems unlikely that the relative debt stock can be a second-order integrated process for a sustained period of time. The recent spike in Ontario debt in the early 1990s is the likely culprit for this result.

Table A2

	ADF Test Results	Phillips-Perron Test Results	I(d) Used for Paper
Ontario:			
$(D_t)^2$	I(2)	I(2)	I(2)
$(D_{ON,t})^2 - (D_{BC,t})^2$	I(1)	I(2)	I(1)
Québec:			
$(D_t)^2$	I(0)	I(1)	I(1)
$(D_{QU,t})^2 - (D_{BC,t})^2$	I(0)	I(1)	I(1)
Nova Scotia:			
$(D_t)^2$	I(1)	I(1)	I(1)
$(D_{NS,t})^2 - (D_{BC,t})^2$	I(1)	I(1)	I(1)

$(D_t)^2$ is the relative debt-to-GDP ratio raised to the second power, and $(D_{j,t})^2 - (D_{BC,t})^2$ is the province j debt-to-GDP ratio squared less the BC debt-to-GDP ratio squared with zeros replacing years recording an accumulated surplus.

The detailed test statistics are reported by province in the following tables. The ADF test results are presented as follows: each column represents a different specification for the test equation. The five percent critical value is reported at the foot of each column for the respective test specification. The optimal lag is listed below the test statistic in parentheses.

The Phillips-Perron results are also reported. The truncation lag, determined by the Schwert formula, is either eight lags or two lags in every case. The critical values are identical in all cases. Tests conducted with a trend have a critical value of 3.57, whereas tests without a trend share a critical value of 2.97.

Both of these tests are conducted on the first difference of the variables in the Ontario case to verify that the variables are not second-order integrated. The other tests are conducted on the Québec and Nova Scotia levels to test for stationarity versus first-order integration. The test results are presented in this format because the Ontario variables are more likely to be I(2) processes, whereas the Québec and Nova Scotia variables were most likely to be I(1).

Ontario-BC Relative Variables
Augmented Dickey-Fuller Test Results for I(1) Processes

Variable	Constant	Constant and Trend	Neither	I(d)
Spread	-5.84 (0 lags)	-5.66 (0 lags)	-5.80 (0 lags)	I(1)
Relative Debt	-2.48 (0 lags)	-2.49 (0 lags)	-2.34 (0 lags)	I(2)
$(D_t)^2$	-1.98 (0 lags)	-2.21 (0 lags)	-1.92 (0 lags)	I(2)
$(D_{ON,t})^2 - (D_{BC,t})^2$	-4.66 (3 lags)	-5.59 (3 lags)	-3.49 (2 lags)	I(1)
Relative Deficit	-6.40 (0 lags)	-6.27 (0 lags)	-6.50 (0 lags)	I(1)
Relative GDP Growth	-6.28 (0 lags)	-6.08 (0 lags)	-6.39 (0 lags)	I(1)
5% Critical Values	-2.99	-3.60	-1.96	

Ontario-BC Relative Variables
Phillips-Perron Test Results for I(1) Processes

Variable	Trend	No Trend	Lag of Test	I(d)
Spread	-6.35 -5.84	-6.37 -5.97	8 2	I(1)
Relative Debt	-2.73 -2.79	-2.75 -2.81	8 2	I(2)
$(D_t)^2$	-2.25 -2.39	-2.23 -2.34	8 2	I(2)
$(D_{ON,t})^2 - (D_{BC,t})^2$	-2.37 -2.64	-2.16 -2.24	8 2	I(2)
Relative Deficit	-7.18 -6.74	-7.50 -7.00	8 2	I(1)
Relative GDP Growth	-7.10 -6.75	-7.34 -7.00	8 2	I(1)
5% Critical Values			8 lags: 3.57 2 lags: 2.97	

Québec-BC Relative Variables

Augmented Dickey-Fuller Test Results for I(0) Processes

Variable	Constant	Constant and Trend	Neither	I(d)
Spread	-2.62 (0 lags)	-2.39 (0 lags)	-1.34 (0 lags)	I(1)
Relative Debt	1.21 (4 lags)	-0.63 (0 lags)	2.42 (4 lags)	I(1), I(0)
$(D_t)^2$	3.22 (4 lags)	1.64 (4 lags)	2.65 (4 lags)	I(0)
$(D_{QU,t})^2 - (D_{BC,t})^2$	4.69 (3 lags)	1.43 (4 lags)	5.88 (4 lags)	I(0)
Relative Deficit	-2.80 (0 lags)	-2.83 (0 lags)	-0.58 (0 lags)	I(1), I(0)
Relative GDP Growth	-3.51 (0 lags)	-3.41 (0 lags)	-3.07 (0 lags)	I(0)
5% Critical Values	-2.98	-3.59	-1.96	

Québec-BC Relative Variables

Phillips-Perron Test Results for I(0) Processes

Variable	Trend	No Trend	Lag of Test	I(d)
Spread	-2.27	-2.43	8	I(1)
	-2.45	-2.59	2	
Relative Debt	-0.66	1.15	8	I(1)
	-1.08	0.46	2	
$(D_t)^2$	2.08	4.43	8	I(1), I(0)
	0.64	2.31	2	
$(D_{QU,t})^2 - (D_{BC,t})^2$	2.89	6.68	8	I(1), I(0)
	0.78	3.28	2	
Relative Deficit	-2.20	-2.15	8	I(1), I(0)
	-3.00	-2.99	2	
Relative GDP Growth	-3.54	-3.69	8	I(0)
	-3.62	-3.76	2	
5% Critical Values			8 lags: 3.57 2 lags: 2.97	

Nova Scotia-BC Relative Variables
Augmented Dickey-Fuller Test Results for I(0) Processes

Variable	Constant	Constant and Trend	Neither	I(d)
Spread	-2.35 (0 lags)	-3.46 (3 lags)	-2.12 (0 lags)	I(1), I(0)
Relative Debt	1.51 (5 lags)	-0.75 (0 lags)	1.60 (0 lags)	I(1)
$(D_t)^2$	1.01 (0 lags)	-0.31 (0 lags)	1.99 (0 lags)	I(0), I(1)
$(D_{NS,t})^2 - (D_{BC,t})^2$	2.39 (5 lags)	0.71 (5 lags)	2.41 (5 lags)	I(1), I(0)
Relative Deficit	-3.68 (0 lags)	-3.84 (0 lags)	-1.92 (0 lags)	I(1), I(0)
Relative GDP Growth	-2.71 (0 lags)	-2.64 (0 lags)	-2.69 (0 lags)	I(1), I(0)
5% Critical Values	-2.99	-3.59	-1.96	

Nova Scotia-BC Relative Variables
Phillips-Perron Test Results for I(0) Processes

Variable	Trend	No Trend	Lag of Test	I(d)
Spread	-2.41 -2.95	-2.20 -2.58	8 2	I(1)
Relative Debt	-0.41 -0.89	0.92 0.44	8 2	I(1)
$(D_t)^2$	0.09 -0.31	1.32 1.05	8 2	I(1)
$(D_{NS,t})^2 - (D_{BC,t})^2$	0.51 0.13	2.67 2.46	8 2	I(1)
Relative Deficit	-4.14 -4.14	-4.39 -4.33	8 2	I(0)
Relative GDP Growth	-2.54 -2.84	-2.63 -2.95	8 2	I(1)
5% Critical Values			8 lags: 3.57 2 lags: 2.97	



Appendix B: Specification Tests

This appendix outlines the results of the LM serial correlation tests, the RESET tests, the Jarque-Bera tests for normally distributed residuals and the residual stationarity tests for the models considered in this study. The appendix is organized into three parts, one for each of the provinces studied. The results derived from the three econometric models are reported for each province.

A. Ontario-BC Models:

The results of the tests for the linear model are reported in Table B1. The results for non-linear model A and B are reported in Tables B2 and B3, respectively.

Table B1: Ontario-BC Linear Model

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion
Serial Correlation LM Test	4	1.99	0.13	No serial correlation up to 4 lags.
Q-statistic for autocorrelated residuals	lag 6	---	0.06	Possible serial correlation of fourth lag.
RESET specification test	2	0.06	0.94	No specification problems.
Jarque-Bera Normality Test	---	1.52	0.47	Cannot reject normally distributed residual.
Residual Stationarity		5% Critical Values		
ADF Results	3 lags	K: -0.21	-2.99	I(1)
	3 lags	K, t: -1.95	-3.6	I(1)
	3 lags	none: -0.46	-1.96	I(1)
Phillips-Perron	8 lags	trend: -5.10	-3.58	I(0)
	8 lags	no trend: -4.33	-2.97	I(0)
	2 lags	trend: -5.05	-3.58	I(0)
	2 lags	no trend: -4.08	-2.97	I(0)

Table B2: Ontario-BC Non-Linear Model A

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion
Serial Correlation LM Test	4 lags	1.92	0.15	No serial correlation problems.
Q-statistic for autocorrelated residuals	lag 4	—	0.07	Possible serial correlation of fourth lag.
RESET specification test	2	0.09	0.92	No specification problems.
Jarque-Bera Normality Test	---	1.49	0.48	Cannot reject normally distributed residual.
<u>Residual Stationarity</u>		5% Critical Values		
ADF Results	3 lags	K: -0.36	-2.99	I(1)
	3 lags	K, t: -1.92	-3.6	I(1)
	3 lags	none: -0.58	-1.96	I(1)
Phillips-Perron	8 lags	trend: -5.14	-3.58	I(0)
	8 lags	no trend: -4.44	-2.97	I(0)
	2 lags	trend: -5.10	-3.58	I(0)
	2 lags	no trend: -4.21	-2.97	I(0)

Table B3: Ontario-BC Non-Linear Model B

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion
Serial Correlation LM Test	4 lags 8 lags	1.28 1.30	0.31 0.31	No serial correlation problems.
Q-statistic for autocorrelated residuals	lag 8	---	0.08	Possible serial correlation of eighth lag.
RESET specification test	1 2	0.53 0.32	0.47 0.73	No specification problems.
Jarque-Bera Normality Test	---	3.56	0.13	Cannot reject normally distributed residual.
<u>Residual Stationarity</u>		<u>5% Critical Values</u>		
ADF Results	3 lags	K: -5.74	-2.99	I(0)
	0 lags	K, t: -5.55	-3.6	I(0)
	3 lags	none: -5.88	-1.96	I(0)
Phillips-Perron	8 lags	trend: -7.42	-3.58	I(0)
	8 lags	no trend: -6.61	-2.97	I(0)
	2 lags	trend: -5.61	-3.58	I(0)
	2 lags	no trend: -5.71	-2.97	I(0)

B. Québec-BC Results

Table B4: Québec-BC Linear Model

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion
Serial Correlation LM Test.	7 lags	3.42	0.045	Serial correlation problem.
Q-statistic for autocorrelated residuals.	lag 6 lag 7 - 16	— —	0.05 p<.05	Autocorrelation of at least sixth lag.
RESET specification test.	1 2 3	1.33 1.42 1.97	0.27 0.28 0.17	No specification problems. Note that before AR(6) correction, there was a bias, at 10% level.
Jarque-Bera Normality Test.	—	1.36	0.51	Cannot reject normally distributed residual.
<u>Residual Stationarity</u>		<u>5% Critical Values</u>		
ADF Results	0 lags	K: -3.91	-3.05	I(0)
	0 lags	K, t: 1.81	-3.76	I(1)
	3 lags	none: -4.01	-1.96	I(0)
Phillips-Perron	8 lags	trend: -4.18	-3.66	I(0)
	8 lags	no trend: -4.62	-3.02	I(0)
	2 lags	trend: -4.18	-3.66	I(0)
	2 lags	no trend: -4.64	-3.02	I(0)

The serial correlation and q-statistic results refer to the model before correcting for autocorrelation problems. The RESET, Jarque-Bera and residual stationarity results apply to the model following an AR(6) transformation, which eliminated the serial correlation problem.

Table B5: Québec-BC Non-Linear Model A

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion
Serial Correlation LM Test.	7 lags	2.83	0.07	Higher order serial correlation problems.
	8 lags	3.28	0.06	
	9 lags	5.57	0.02	
Q-statistic for autocorrelated residuals.	lag 6	—	0.06	Autocorrelation of at least sixth lag.
	lags 7-12	—	p<.05	
RESET specification test.	1	0.65	0.43	No specification problems.
	2	1.02	0.39	
	3	0.76	0.54	
Jarque-Bera Normality Test.	—	0.9	0.64	Cannot reject normally distributed residual.
<u>Residual Stationarity</u>		5% Critical Values		
ADF Results	0 lags	K: -4.18	-3.05	I(0)
	5 lags	K, t: 1.79	-3.76	I(1)
	0 lags	none: -4.32	-1.96	I(0)
Phillips-Perron	8 lags	trend: -4.65	-3.66	I(0)
	8 lags	no trend: -5.06	-3.02	I(0)
	2 lags	trend: -4.62	-3.66	I(0)
	2 lags	no trend: -5.04	-3.02	I(0)

Table B6: Québec-BC Non-Linear Model B

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion
Serial Correlation LM Test.	2 lags	4.83	0.02	Higher order serial correlation problems.
	3 lags	4.69	0.01	
	6 lags	3.69	0.01	
	7 lags	3.08	0.03	
Q-statistic for autocorrelated residuals.	lags 1 through 9	—	p<0.05	Autocorrelation problems are evident.
RESET specification test.	1	5.97	0.03	Specification problems exist after correcting for AR(6) errors.
	2	2.82	0.09	
	3	1.89	0.18	
Jarque-Bera Normality Test.	—	1.51	0.47	Cannot reject normally distributed residual.
Residual Stationarity		5% Critical Values		
ADF Results	0 lags	K: -4.12	-3.05	I(0)
	3 lags	K, t: -0.29	-3.71	I(1)
	3 lags	none: -1.02	-1.96	I(1)
Phillips-Perron	8 lags	trend: -4.53	-3.66	I(0)
	8 lags	no trend: -4.93	-3.02	I(0)
	2 lags	trend: -4.52	-3.66	I(0)
	2 lags	no trend: -4.93	-3.02	I(0)

C. Nova Scotia-BC Results:

Table B7: Nova Scotia-BC Linear Model

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion	
Serial Correlation LM Test.	1 lag	0.68	0.42	Possible second-order serial correlation.	
	2 lags	2.58	0.1		
	3 lags	1.95	0.15		
Q-statistic for autocorrelated residuals.	16 lags	—	$p>0.1$ $\forall i \in (1,16)$	No autocorrelation problems.	
RESET specification test.	1	1.91	0.18	No specification problems.	
	2	0.93	0.41		
Jarque-Bera Normality Test.	—	0.42	0.81	Cannot reject normally distributed residual.	
<u>Residual Stationarity</u>		<u>5% Critical Values</u>			
ADF Results	0 lags	K:	-4.3	-2.98	I(0)
	0 lags	K, t:	-4.29	-3.00	I(1)
	3 lags	none:	-4.39	-1.95	I(1)
Phillips-Perron	8 lags	trend:	-4.61	-3.57	I(0)
	8 lags	no trend:	-4.42	-2.97	I(0)
	2 lags	trend:	-4.42	-3.57	I(0)
	2 lags	no trend:	-4.44	-2.97	I(0)

Table B8: Nova Scotia-BC Non-Linear Model A

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion
Serial Correlation LM Test	1 lag	0.92	0.35	Possible second-order serial correlation.
	2 lags	2.47	0.11	
	3 lags	1.98	0.15	
Q-statistic for autocorrelated residuals.	16 lags	—	$p > 0.1$ $\forall i \in (1, 16)$	No autocorrelation problems.
RESET specification test.	1	3.26	0.08	Specification problem at 10% level.
	2	1.62	0.22	
	3	1.63	0.21	
Jarque-Bera Normality Test.	—	0.53	0.77	Cannot reject normally distributed residual.
Residual Stationarity				
			5% Critical Values	
ADF Results	0 lags	K: -4.3	-2.98	I(0)
	0 lags	K, t: -4.29	-3.00	I(1)
	3 lags	none: -4.39	-1.95	I(1)
Phillips-Perron	8 lags	trend: -4.61	-3.57	I(0)
	8 lags	no trend: -4.42	-2.97	I(0)
	2 lags	trend: -4.42	-3.57	I(0)
	2 lags	no trend: -4.44	-2.97	I(0)

Table B8: Nova Scotia-BC Non-Linear Model B

Test / Specification	Lags / Fitted Values	Test Statistic	p-value	Conclusion
Serial Correlation LM Test.	1 lag	0.92	0.35	Possible second-order serial correlation.
	2 lags	2.47	0.11	
	3 lags	1.98	0.15	
Q-statistic for autocorrelated residuals.	lag 2	---	0.07	Possible second-order autocorrelation problem.
RESET specification test.	1	3.20	0.09	Specification problem at 10% level.
	2	1.80	0.19	
	3	1.49	0.25	
Jarque-Bera Normality Test.	—	0.61	0.74	Cannot reject normally distributed residual.
Residual Stationarity		5% Critical Values		
ADF Results	1 lags	K: -4.97	-2.99	I(0)
	1 lags	K, t: -4.97	-3.60	I(0)
	1 lags	none: -5.07	-1.96	I(0)
Phillips-Perron	8 lags	trend: -4.96	-3.58	I(0)
	8 lags	no trend: -4.95	-2.97	I(0)
	2 lags	trend: -4.61	-3.58	I(0)
	2 lags	no trend: -4.78	-2.97	I(0)

An AR(2) correction for possible serial correlation results in specification errors, as indicated by the RESET test. As a result, since the serial correlation problem is only at the 11% significance level, the model is not corrected for the possible error.

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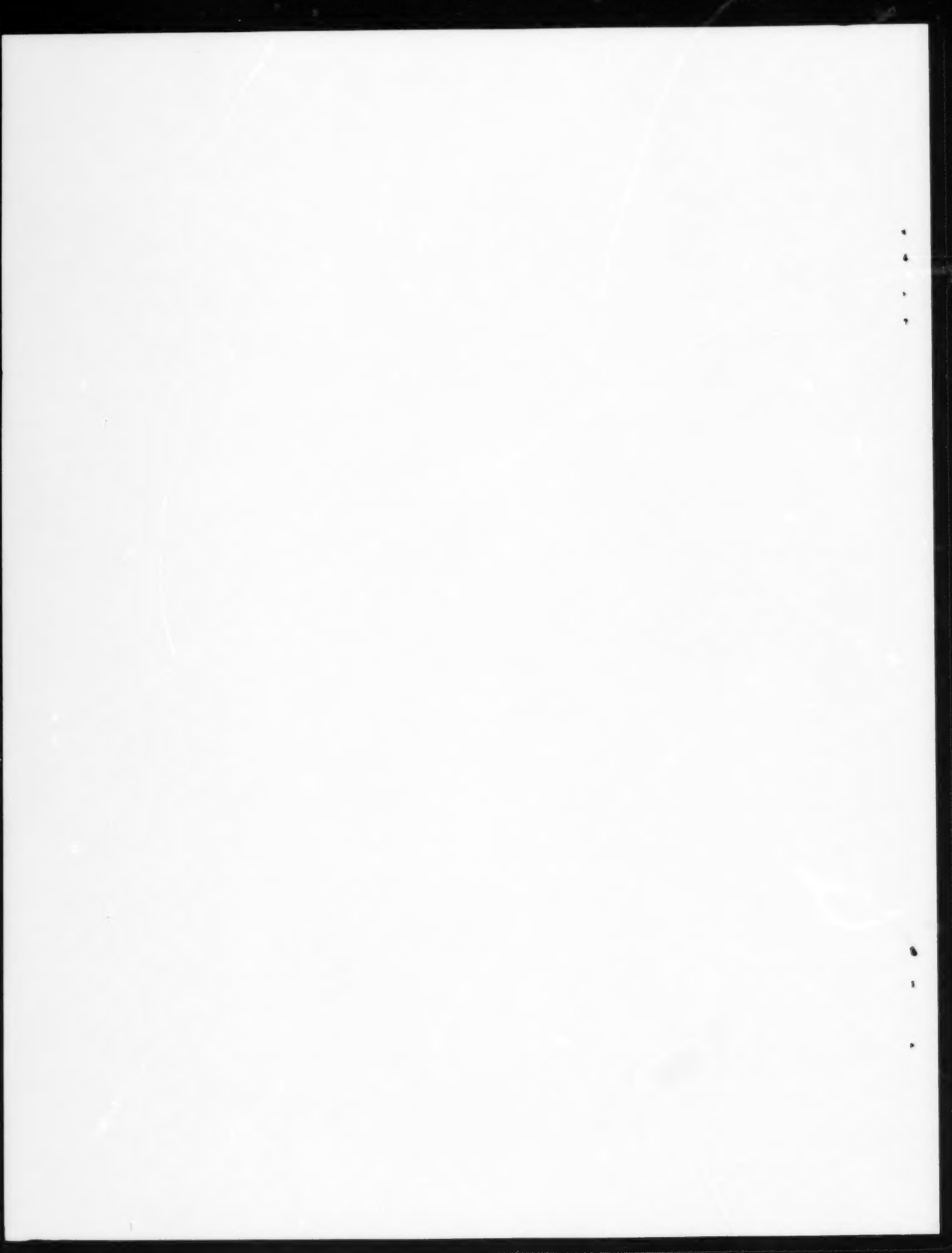
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